REMARKS

Claims 1-13 are pending herein.

The claims have been respectfully amended.

The amendment in claim 1 is based on original claim 11 and p. 38 line 3 to p. 39 line 1 of the specification. Thus, no new matter has been introduced.

The anticipation rejections based on Zimmerman (US 6,481,648).

The USPTO respectfully rejects Claims 1-4, 6, 7, 9, 10 and 13 under 35 U.S.C. § 102(e) as being anticipated by Zimmerman. Further, dependent claims 5, 11 and 12 stand rejected as obvious over Zimmerman.

Claim 1 has been amended to further limit the nozzle diameter to not more than 8 μm. In claim 1, it is intended to induce electric field concentration effectively by minimizing the nozzle diameter. On the other hand, Zimmerman teaches neither the nozzle diameter of not more than 8 μm nor the effect of electric field concentration.

The following is an example of the effect of electric field concentration, and shows maximum electric field intensities in the condition where nozzle diameter is 8 μm and jetting voltage applied between the nozzle and the counter electrode is 200 V, and distance from the nozzle to the counter electrode (gap) is 100 μm or 2000 μm, which are also shown in Fig. 7 of the present specification.

5.10196×10^7 V/m (gap: 100 μm)

5.005×10^7 V/m (gap: 2000 μm)

Such high electric field intensity can be obtained because the electric field is concentrated to the convex meniscus formed by the liquid solution at the nozzle edge portion. In contrast, the following is electric field intensities in a normal parallel electric field where 200 V voltage is applied, which are calculated as dividing voltage with gap distance.

2.0×10^6 V/m (gap: 100 μm)

1.0×10^5 V/m (gap: 2000 μm)

As shown above, the structure of claim 1 is successful in utilizing much larger effect of electric field than in the case of normal electric filed.

Specifically, electrostatic force to jet a droplet is about 25 folds larger in the case of 100 μm gap, and is about 500 folds larger in the case of 2000 μm gap. Generally, it is required to apply high voltage of several kV in order to jet a droplet fly only by electrostatic force in normal condition.

However, according to claim 1, it becomes possible to jet a droplet with fairly low voltage of several hundreds V. That is, it becomes possible to jet a droplet by remarkably lower energy than in normal condition. Furthermore, as seen in the above example, when the nozzle diameter is 8 μm or less so as to make electric field concentrate, the maximum electric field intensity is hardly affected by a gap distance. Thus, the present invention is advantageous in stable jetting of droplets (also see Fig. 7).

Since an effect of electric field concentration is utilized, the structure of claim 1 is successful in jetting droplets from a nozzle whose nozzle diameter is too small to jet droplets only by vibration energy of a piezoelectric vibrator. Thus, it becomes possible to attain ink-jet printing with smaller droplets.

Also, claim 1 also has been amended to recite that at least the edge portion of the nozzle is formed with insulating material. The insulating material is to prevent electricity leaking from the nozzle to the counter electrode due to electric field concentration (see p.38 line 3 to p.39 , line 1 of the specification). When the leakage of electricity occurs, the electric field formed between the nozzle and counter electrode lowers and jetting of a droplet becomes impossible. Since the insulating material is employed in the present invention, jetting of a droplet is ensured even if effect of electric field concentration is actively utilized.

The USPTO respectfully argues that the feature of the nozzle diameter of not more than 4 or 8 μm is obvious over Zimmerman by further referring to Rodenberger et al. (US 5165161B). Zimmerman discloses a microchip of electrospray for introducing a liquid

sample to a mass spectrometer. Rodenberger discloses a conical-shaped nozzle whose front portion is notched wherein the nozzle is constituted from two parts and a shim sandwiched therebetween, and also discloses that the thickness of the shim is about from 25 μm to 408 μm.

However, none of the references teach the nozzle having ultra fine diameter of 8 μm or less. Thus, this feature of claim 1 is not obvious from a combination of these references. Please see MPEP 706.02(j).

Furthermore, Rodenberger discloses that electric charge is concentrated to liquid due to the sharper distal end or tip 44 (column 6 1.14-23). However, since the distal end of the nozzle disclosed by Rodenberger is notched, liquid at the distal end is located at outside of the nozzle. Rodenberger does not teach or suggest that electric field intensity extremely increases at the nozzle edge portion by minimizing the nozzle diameter, but only discloses such high applied voltage of 15 kV. Therefore, it is believed that a skilled person would not employ a nozzle of micro diameter so as to make possible to jet fine droplets with low jetting voltage.

Moreover, none of Zimmerman and Rodenberger teaches or suggests that an inside passage length of the nozzle is set to at least not less than ten times of the inside diameter of the nozzle at the nozzle edge portion so as to improve response of the fine nozzle.

In view of the foregoing, the claimed invention is not anticipated by and is not obvious over any of the references. Thus, amended claims are patentable and the present application now stands for allowance.

The claim rejections based on nonstatutory obviousness-type double patenting.

The USPTO respectfully provisionally rejects Claims 1-7 and 9-13 on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claim 1 of copending Application No. 10/529,006.

Claim 1 has been amended in both cases so that this rejection is no longer believed to apply.

Also, since neither the present claims nor the claims of copending Application Serial No. 10/529,006 have been patented, it is respectfully not possible that double patenting can be determined (nothing is patented and there is no way to compare the final claims until one of the cases has been patented and the other claims are otherwise allowable). Thus, the Applicants respectfully request that the USPTO withdraw the provisional obviousness double patenting rejections until the claims are in final form and otherwise in condition for allowance, and also until the case over which double patenting is alleged is allowed.

Conclusion.

Reconsideration and allowance of all of the claims is respectfully requested.

If there are any additional charges with respect to this Amendment or otherwise, please charge them to Deposit Account No. 06-1130.

Please contact the undersigned for any reason. Applicants seek to cooperate with the Examiner including via telephone if convenient for the Examiner.

Respectfully submitted,

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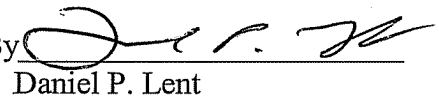
By 
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